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AN ECONOMETRIC MODEL OF P.E.I. AGRICULTURAL SECTOR WITH MAJOR EMPHASIS ON POTATO SECTOR*

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INTRODUCTION

Agriculture plays a vital role in Prince Edward Island (P.E.I.), the smallest and poorest Canadian province. In 1981, the agricultural sector accounted for 12.0 percent of the provincial gross domestic product (at factor cost), as compared to the manufacturing sector's contribution of 10.0 percent. Almost 75 percent of the manufacturing in P.E.I. is primarily agriculture-based.

P.E.I.'s single most important agricultural product is potatoes; it contributes about one-third to total farm cash receipts. The high production level (accounts for 20 - 25 percent of the total Canadian potato production) and small population have made P.E.I. one of the leading exporters of potatoes, accounting for more than 50 percent of the total Canadian export.

The fluctuations in potato prices, production and exports have significant impact on the economy of P.E.I. which is heavily dependent on potato income.

Several agricultural sector models have been constructed at the national level (for example, Fox, 1965; Evans, 1969; Chen, 1977; Chan, 1981). There have also been several econometric models for individual agricultural commodities or commodity-groups at the national level or for large economies (for example, Agriculture Canada, 1978; Arzac and Wilkinson, 1979; Heien, 1975). In this present paper we have developed a model of the P.E.I. agricultural sector with major emphasis on the potato sector. The model is used to analyze the effects of changes in the exogenous variables such as potato production levels in the United States (a competitive exporter as well as an important buyer of P.E.I. potatoes), and Netherlands (a major international exporter of potatoes), exchange rate, Canadian and P.E.I. personal disposable incomes, interest rate, wage rate, and farm capital stocks on the agricultural economy.

The organization of this paper is as follows. Section 2 gives a brief background of the potato sector. Section 3 contains the model specification, and Section 4 the estimation of the model. The results of estimation of impact analysis are discussed in Section 5. Section 6 presents some simulation results. Finally, Section 7 presents a brief summary.

2. THE P.E.I. POTATO SECTOR

The trend in the province's potato production shows considerable growth over time (see Table 1). The only other province to experience high production growth is Manitoba. In other provinces, potato production either has declined or has increased at a very slow rate.

The increase in potato production has been the result of an increase in potato acreage as well as increase in yield. Since the early fifties, there has been an increase of about 70 percent in potato acreage in P.E.I. (see Table 2). This again is very much in contrast with the other provinces (with the exception of Manitoba) where potato acreage has either declined or remained roughly the same.

P.E.I. exports about two-thirds of its potato crop to other Canadian provinces, the United States, and other countries (among them are Venezuela, Italy, Uruguay, Barbados, Trinidad, and Algeria) in the form of both seed and table potatoes (see Table 2).

The prices of P.E.I. potatoes are very unstable. The price fluctuation is partly explained by fluctuation in potato production which is one important determinant of the prices. In general, prices fall when production is high, and vice versa. As can be seen from Table 2, potato prices were generally low until the early seventies, and fluctuation in the prices has been very sharp in the recent years.

TABLE 1

POTATOES P.E.I.
Estimated Acreage, Production, Farm Price and Value

Year	Seeded Area (acres)	Average Yield cwt. per acre	Production '000 cwt.	Average Farm Price $ per cwt.	Total Farm Value $ '000
1952	36,000	180.0	6,480	2.07	13,392
1953	41,000	163.8	6,716	0.80	5,371
1954	40,500	150.0	6,075	2.12	12,859
1955	43,000	165.0	7,095	1.32	9,342
1956	42,500	165.0	7,012	1.48	10,378
1957	46,300	195.0	9,028	1.30	11,736
1958	46,400	175.0	8,120	1.30	10,556
1959	42,000	152.7	6,413	2.61	16,738
1960	45,000	160.0	7,200	1.48	10,656
1961	46,200	165.0	7,623	0.91	6,937
1962	39,000	191.3	7,462	1.43	10,671
1963	41,000	204.4	8,300	1.50	12,450
1964	40,000	209.3	8,372	2.90	24,279
1965	44,000	166.8	7,341	2.55	18,720
1966	52,100	206.8	10,776	1.09	10,187
1967	51,000	188.4	9,607	1.37	11,126
1968	53,000	208.8	11,066	1.15	10,537
1969	50,000	214.2	10,710	2.01	18,546
1970	51,000	201.0	10,252	1.55	11,614
1971	46,800	199.4	9,332	1.42	10,701
1972	39,000	224.1	8,740	3.80	28,145
1973	42,000	227.5	9,553	6.20	51,193
1974	52,000	238.5	12,400	2.69	23,176
1975	46,000	202.0	9,281	5.98	51,569
1976	51,600	241.0	12,457	4.38	48,546
1977	55,000	217.0	11,913	2.45	22,316
1978	56,000	221.0	12,067	3.34	32,155
1979	61,000	249.0	15,195	2.76	30,965
1980	56,000	233.0	13,025	8.78	95,236
1981	64,000	253.0	16,192	4.78	62,653

Sources: The 1977 Potato Handbook, 1978, Galvin Publishing Company, 384 City National Building, Detroit, Michigan.

Statistics Canada, Agricultural Division, Crops Section, Reference Handbook, Vegetables, June 1978 and December 1979 issues.

Statistics Canada, "Fruit and Vegetable Production", May 1981, June 1982, and July 1982 issues.

TABLE 2

DISPOSITION OF POTATOES--P.E.I.
('000 cwts.)

Year	Shipments		Local Use Seed and Processing	Cullage and Loss	Total
	Table	Seed			
1956	3759.4	1498.6	732.6	1021.4	7012.0
1957	5237.0	1719.0	775.0	1297.0	9028.0
1958	4851.0	1279.8	731.2	1258.0	8120.0
1959	3842.5	961.4	549.0	1015.1	6413.0
1960	3936.8	1115.5	642.0	1505.7	7200.0
1961	4777.0	1147.9	614.0	1084.1	7623.0
1962	4376.4	1425.0	644.0	1016.6	7462.0
1963	4982.6	1376.3	795.1	1146.0	8300.0
1964	5039.8	1482.7	791.2	1058.3	8372.0
1965	4167.2	1362.9	914.0	896.9	7341.0
1966	5349.8	1840.8	1224.8	2360.6	10776.0*
1967	5302.1	1381.3	1405.8	1517.8	9607.0
1968	6000.8	1618.1	1544.3	1902.8	11066.0
1969	5853.8	1711.6	1662.0	1482.6	10710.0
1970	4297.3	1574.0	1770.7	2610.0	10252.0
1971	4484.1	1077.4	1666.4	2104.1	9332.0*
1972	4927.8	1077.7	1401.0	1333.5	8740.0
1973	5076.2	1432.4	1748.3	1296.1	9553.0
1974	5262.6	1059.5	3932.6	2145.2	12400.0*
1975	4706.0	1453.2	2464.3	657.5	9281.0
1976	6525.7	1560.7	2970.2	1400.4	12457.0
1977	4762.8	1659.4	2848.0	2642.8	11913.0
1978	5100.2	1627.5	3031.9	2626.4	12386.0
1979	5900.9	1882.1	3348.4	3965.0	15195.4*
1980	5861.5	2761.1	2222.8	2179.6	13025.0
1981	7494.1	2311.1	3292.3	3094.3	16192.0

* Includes Potatoes Disposed of under A.S.B. Diversion Program.

Source: Agricultural Statistics 1980
Province of Prince Edward Island
Department of Agriculture and Forestry, 1981.

3. SPECIFICATION OF THE MODEL

Supply function for potatoes is specified as a response function. The quantity supplied in any year depends upon the price in the previous year. Since about two-thirds of the potato crop is exported, the export performance also influences the supply one year later. Both lagged variables are expected to have a positive influence on the supply. The trend variable captures the secular increase in potato production due to technological and other factors. The supply equation is:

$$(1) \quad OPI_t = f\ (PPI_{t-1},\ EXPT_{t-1},\ t)$$

where OPI_t is the potato production (P.E.I.), million cwt.; PPI_{t-1} is the average farm price of potatoes (P.E.I.) in the previous year, dollars per cwt.; $EXPT_{t-1}$ is the total exports of potatoes in the previous year, million cwt.; and t is the trend variable.

The price of P.E.I. potatoes is affected by the quantity supplied.[1] Potato production in the United States, an important market for P.E.I. potatoes, also affects the P.E.I. potato price. Both these variables are expected to have negative signs. Canadian personal disposable income is expected to have positive influence on the potato price. The price equation takes the form:

$$(2) \quad PPI_t = f\ (OPI_t,\ OPUS_t,\ LPDIC_t)$$

where PPI_t is the average farm price of potatoes (P.E.I.), dollars per cwt., $OPUS_t$ is the potato production in the United States, million metric tons; and $LPDIC_t$ is the personal disposable income (in log form), Canada, billion dollars.

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1. As an example of this type of relationship, Tobin (1956) in his classic study of demand for food in the U.S.A. for 1913-41 estimates an equation with price as the dependent variable and quantity supplied as one of the explanatory variables.

Once price is determined, equations for disposition of potatoes can be formulated.

High potato prices induce the farmers to export more in the international market. The exports to foreign countries, referred to as external exports, are thus positively influenced by price. The external exports are also positively related to the supply because, in the case of a good crop, a substantial portion of surplus potatoes can be disposed of in the huge international market. The Netherlands potato production, a proxy for potato production in the major potato exporting countries, has negative effect on the external exports. Finally, the external exports are affected by exchange rate, low value of Canadian dollar resulting in more exports. The specification, thus, takes the form:

$$(3) \quad EXPF_t = f\ (OPI_t, PPI_t, OPN_t, R_t)$$

where $EXPF_t$ is the external exports, million cwt.; OPN_t is the Netherlands potato production, million metric tons; and R_t is the price of U.S. dollar in Canadian funds.

Demand for P.E.I. potatoes in the rest of Canada, referred to as internal exports, is primarily determined by potato price. Price of substitutes, cereals and bakery products[2], has positive influence on the internal exports. In Western Canada, Canadians import significant quantity of potatoes from the U.S.A. The U.S. potato production thus has a negative effect on the

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2. Zusman (1962) quotes a study of consumers' preference for potatoes by the U.S. Department of Agriculture which suggests that the main substitutes are macaroni, spaghetti, noodles, and rice, and to a lesser extent other vegetables. In his study, the index of retail price of cereals and bakery products is used as one of the explanatory variables in potato demand equation.

internal exports. The specification, therefore is:

$$(4) \quad EXPRC_t = f\ (PPI_t,\ PSC_t,\ OPUS_t)$$

where $EXPRC_t$ is the internal exports, million cwt.; and PSC_t is the consumer price index of cereals and bakery products (1971 = 100), Canada.

Domestic demand for potatoes depends on potato price and the price of the substitutes. The province's real personal disposable income is expected to have a positive effect on the domestic demand. The domestic demand equation is:

$$(5) \quad DDI_t = f\ (PPI_t,\ PSC_t,\ RDPII_t)$$

where DDI_t is the domestic utilization of potatoes, million cwt.; and $RDPII_t$ is the real personal disposable income, P.E.I., million dollars.

Farm value of potatoes is assumed to be a statistically determined function rather than expressing as a product of potato price and the quantity sold.

$$(6) \quad FMV_t = f\ (PPI_t,\ OPI_t)$$

where FMV_t is the farm value of potatoes, P.E.I., million dollars.

Farm cash receipts from potatoes depend on the lagged and current farm value of potatoes.

$$(7) \quad CRP_t = f\ (FMV_t,\ FMV_{t-1})$$

where CRP_t is the farm cash receipts from potatoes, P.E.I., million dollars; and FMV_{t-1} is the lagged farm value of potatoes, million dollars.

Farm cash receipts from other crops depend on the lagged farm cash receipts from other crops and the trend variable.

$$(8) \quad CROC_t = f\ (CROC_{t-1},\ t)$$

where $CROC_t$ is the farm cash receipts from other crops, P.E.I., million dollars; and $CROC_{t-1}$ is the lagged farm cash receipts from other crops.

Farm cash receipts from the livestock sector depend on farm capital in the form of livestock and poultry and the trend variable:

(9) $CRL_t = f\ (KL_t, t)$

where CRL_t is the farm cash receipts from the livestock sector, P.E.I., million dollars; KL_t is the value of farm capital in the form of livestock and poultry, P.E.I., million dollars.

Investment in the agricultural sector in the form of implements and machinery is positively related to the lagged farm cash receipts from potatoes and other agricultural sectors. Rate of interest has negative influence on the investment. The investment equation is:

(10) $INVM_t = f\ (CRP_{t-1}, CRN_{t-1}, IR_t)$

where $INVM_t$ is the investment in the agricultural sector in the form of implements and machinery, P.E.I., million dollars; CRN_{t-1} is the lagged farm cash receipts from agricultural goods other than potatoes; IR_t is the yield on industrial bonds, Canada.

Employment in agriculture is negatively related to agricultural wage rate. In a region with high unemployment and very little job opportunity in industry, family labour is as significant as hired labour in the total agricultural employment. For this reason, unemployment is also included as an explanatory variable in the labour demand equation. Farm capital in the form of implements and machinery has positive effect on the employment. The secular decline in agricultural employment is captured by the trend variable:

(11) $N_t = f\ (WR_t, UN_t, KM_t, t)$

where N_t is the employment in agriculture, P.E.I.; WR_t is the real average wages of farm help per day (without board), Maritimes, dollars; UN_t is the rate of unemployment, P.E.I.; KM_t is the value of farm capital in the form of implement and machinery, P.E.I., million dollars.

Agricultural investment in the form of implements and machinery and change in agricultural employment cause changes in agricultural output:

$$(12) \quad \Delta IAGQ_t = f\ (\Delta N_t,\ INVM_t)$$

where $\Delta IAGQ$ is the change in index of farm production, P.E.I., 1971 = 100.

There are four additional identities which complete the system. The total exports are equal to the external exports and the internal exports:

$$(13) \quad EXPT_t = EXPF_t + EXPRC_t$$

The farm cash receipts from other agricultural sectors are equal to the farm cash receipts from other crops and the farm cash receipts from the livestock sector:

$$(14) \quad CRN_t = CROC_t + CRL_t$$

Investment and capital stock in the agricultural sector in the form of implements and machinery are related in the following way:

$$(15) \quad KM_t = INVM_t + KM_{t-1}$$

where KM_{t-1} is the lagged value of farm capital in the form of implements and machinery, P.E.I., million dollars.

Finally, a balance between the supply of potatoes and the disposition of potatoes is established by a cullage and loss factor. Changes in storage holdings are not significant relative to production so they are not included in the model.

$$(16) \quad CULL_t = OPI_t - EXPF_t - EXPRC_t - DDI_t$$

where $CULL_t$ is the cullage and loss.

4. ESTIMATION OF THE MODEL

In order to obtain consistent parameter estimates, the structural equations of the model were estimated using two-stage least squares. In general, the equations were estimated using annual data from the period 1952-81.[3] The estimated behavioral equations with their t-ratios (numbers beneath the regression coefficients), the adjusted coefficients of multiple determination, $\bar{R}^2$, the Durbin-Watson statistic (except for the equations which have lagged endogenous variables as independent variables) are given below. Standard error of estimate (SEE) is also given for the equations for which simulations are reported.

(1) $OPI_t = 3.030 + 0.347\ PPI_{t-1} + 0.427\ EXPT_{t-1} + 0.189t$

(2.00) (2.41) (1.50) (5.46)

$\bar{R}^2 = .803$ SEE = 1.153

(2) $PPI_t = -0.383 - 0.683\ OPI_t - 0.864\ OPUS_t + 5.372\ LPDIC_t$

(.31) (3.45) (5.22) (8.47)

$\bar{R}^2 = .793$ D.W. = 2.05 SEE = .837

(3) $EXPF_t = -8.389 + 0.059\ OPI_t + 0.110\ PPI_t - 0.175\ OPN_t + 9.553\ R_t$

(3.19) (0.544) (2.26) (0.649) (3.03)

$\bar{R}^2 = .940$ D.W. = 2.06 SEE = .342

(4) $EXPRC_t = 12.713 - 0.577\ OPUS_t - .224\ PPI_t + .952\ PSC_t$

(4.64) (2.95) (2.02) (2.57)

$\bar{R}^2 = .266$ D.W. = 1.80 SEE = .578

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3. The main sources of data are: The Potato Handbook, 1973; P.E.I. Agricultural Statistics, 1982; various Statistics Canada publications; and FAO Production Yearbooks.

(5) $DDI_t = -0.575 - 0.190\ PPI_t + 0.012\ RDPII_t + 0.088\ PSC_t$

(3.17) (2.84) (6.43) (.344)

$\bar{R}^2 = .865$ D.W. = 1.53 SEE = 0.367

(6) $FMV_t = -20.893 + 9.442\ PPI_t + 1.985\ OPI_t$

(5.25) (17.87) (4.70)

$\bar{R}^2 = .960$ D.W. = 1.95 SEE = 3.962

(7) $CRP_t = -2.659 + 0.276\ FMV_t + 0.676\ FMV_{t-1}$

(3.24) (10.66) (24.42)

$\bar{R}^2 = .983$ SEE = 2.198

(8) $CROC_t = -0.766 + .881\ CROC_{t-1} + .241t$

(.718) (5.011) (1.430)

$\bar{R}^2 = .915$

(9) $CRL_t = -6.011 + 0.735\ KL_t + 0.77t$

(0.15) (14.78) (5.63)

$\bar{R}^2 = 0.986$ D.W. = 1.65

(10) $INVM_t = 1.784 - 0.413\ IR_t + 0.081\ CRP_{t-1} + 0.247\ CRN_{t-1}$

(0.77) (0.85) (1.34) (4.38)

$\bar{R}^2 = 0.871$

(11) $N_t = 7.988 - 0.062\ WR_t - 0.081\ UN_t + 0.013\ KM_t - 0.141t$

(5.99) (.467) (.753) (1.56) (1.73)

$\bar{R}^2 = .543$ D.W. = 2.17

(12) $\Delta IAGO_t = 3.372 + 7.896\ DN_t + 0.226\ INVM_t$

(0.59) (3.18) (0.351)

$\bar{R}^2 = 0.468$

5. ANALYSIS OF RESULTS

As expected, the supply of potatoes was found to be positively related to the lagged price and the lagged total exports, although the relation to the latter was relatively weak. The trend variable also positively affected the supply.

Price of potatoes was found to be negatively related to the supply of potatoes with a high supply elasticity of -2.51. The effect of the U.S. potato production on the price was even higher. The personal Canadian disposable income was positively and strongly related to the price.

External exports were found to be positively related (though insignificant) to the supply, a one unit increase in the supply raising the exports by .059 units. The price and the exchange rate were also positively related to the external exports. The Netherlands potato production was found to have an insignificant negative effect on the external exports.

Internal exports were found to be negatively related to the price. The demand for P.E.I. potatoes in the Canadian market (excluding P.E.I.) was, however, inelastic (the price elasticity equal to -.11). The effect of the U.S. potato production on the internal exports was, as expected, significantly negative. The price of the substitutes was found to have a significant positive effect on these exports.

Domestic demand for potatoes was also inelastic with a price elasticity equal to -.30. The effect of the price of the substitutes on the demand was positive, but it was insignificant. The real personal disposable income (P.E.I.) was positively and strongly related to the demand.

Farm value of potatoes was positively and strongly related to the price. The effect of the supply on the farm value of potatoes was also strongly positive.

Cash receipts from potatoes were positively and strongly related to the current and lagged farm value of potatoes, the latter having a more significant effect.

Cash receipts from the livestock sector were positively and significantly related to the farm capital in the form of livestock and poultry, a one unit increase in the capital stock raising the cash receipts by .735 units. The effect of the trend variable was also positive and significant.

Investment in agriculture in the form of implements and machinery was negatively related to interest rate with an interest elasticity equal to -.614. The interest coefficient was, however, insignificant. The lagged cash receipts from potatoes and from other agricultural sectors were both found to have positive effect on the investment, although the effect of the former was relatively small (about one-third of the latter) and insignificant.

Employment in agriculture was negatively related to agricultural wage rate, a one dollar (real) increase in daily farm wages reducing agricultural employment by 62. The wage rate elasticity was found to be -.109. The wage rate coefficient was, however, insignificant. Rate of unemployment was found to have an insignificant negative effect on agricultural employment, a one percentage point increase in unemployment rate reducing agricultural employment by 81. Farm capital in the form of implements and machinery positively affected the agricultural employment, an increase of one million dollars in the farm capital raising agricultural employment by 13. The trend variable was found to have a negative effect on agricultural employment.

Change in agricultural output was positively, but insignificantly, related to agricultural investment in the form of implements and machinery. Change in agricultural employment was found to have significant positive effect on change in agricultural output.

Reduced Form Equations

The structural system can be solved for the endogenous variables to obtain the reduced form of the system. The reduced form expresses each endogenous variable as a linear function of the several pre-determined variables, including the lagged endogenous variables. A matrix formulation of the structural system is as follows:

$$AY_t + B_1Y_{t-1} + B_2Z_t = U_t$$

where A is a matrix of coefficients of current endogenous variables, B_1 is a matrix of coefficients of lagged endogenous variables, and B_2 is a matrix of coefficients of exogenous variables.

The reduced form of the model may be written:

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Z_t + V_t$$

where $\Pi_1 = -A^{-1}B_1$ and $\Pi_2 = -A^{-1}B_2$

The reduced form equations show both direct and indirect effects of a change in any predetermined variables on each endogenous variable, while maintaining the relationships among variables implicit in the structure. For this reason, the reduced form coefficients are often referred to as impact or short-run multipliers. This multiplier analysis can help decision-makers in finding answers to some of the questions pertinent to the P.E.I. potato sector and the agricultural sector. The reduced form equations of the model, along with the RMS error defined in the next section, are presented below.

(R-1) $OPI_t = 3.030 + 0.347\ PPI_{t-1} + 0.427\ EXPT_{t-1} + 0.189\ t$

RMS Error = 1.111

(R-2) $PPI_t = -2.452 - 0.237\ PPI_{t-1} - 0.291\ EXPT_{t-1} - 0.864\ OPUS_t - 0.129t + 5.372\ LPDIC_t$

RMS Error = 0.990

(R-3) $EXPF_t = -8.48 - 0.006\ PPI_{t-1} - 0.007\ EXPT_{t-1} - 0.095\ OPUS_t - 0.003t + 0.590\ LPDIC_t - 0.175\ OPN_t + 9.553\ R_t$

RMS Error = .252

(R-4) $EXPRC_t = 13.262 + 0.053\ PPI_{t-1} + 0.065\ EXPT_{t-1} - 0.384\ OPUS_t + 0.028t - 1.203\ LPDIC_t + 0.952\ PSC_t$

RMS Error - .523

(R-5) $DDI_t = -0.110 + 0.045\ PPI_{t-1} + 0.055\ EXPT_{t-1} + 0.164\ OPUS_t + 0.024t - 1.020\ LPDIC_t + 0.088\ PSC_t + 0.012\ RDPII_t$

RMS Error = .383

(R-6) $FMV_t = -38.03 - 1.549\ PPI_{t-1} - 1.900\ EXPT_{t-1} - 8.157\ OPUS_t - 0.843t + 50.722\ LDPIC_t$

RMS Error = 10.263

(R-7) $CRP_t = -13.155 - 0.427\ PPI_{t-1} - 0.524\ EXPT_{t-1} - 2.251\ OPUS_t - 0.232t + 13.999\ LDPIC_t + .676\ FMV_{t-1}$

RMS Error = 3.411

(R-8) $CROC_t = -0.766 + 0.881\ CROC_{t-1} + .241t$

(R-9) $CRL_t = -6.011 + 0.735\ KL_t + 0.77t$

(R-10) $INVM_t = -1.784 - 0.413\ IR_t + 0.081\ CRP_{t-1} + 0.247\ CROC_{t-1} + 0.247\ CRL_{t-1}$

(R-11) $N_t = 7.965 - 0.081\ UN_t - 0.062\ WR_t - 0.005\ IR_t + 0.001\ CRP_{t-1} + 0.003\ CROC_{t-1} + .003\ CRL_{t-1} + 0.013\ KM_{t-1} - 0.141t$

(R-12) $\Delta IAGQ_t = 65.86 - 0.639\ UN_t - 0.489\ WR_t - 0.132\ IR_t + 0.025\ CRP_{t-1} + 0.078\ CROC_{t-1} + 0.078\ CRL_{t-1} + 0.102\ KM_t - 1.113t + 7.896\ N_{t-1}$

The effect of a change in any one, or all, of the predetermined variables on any one or all of the endogenous variables in the model can be easily measured from the above equations. For example, a change in lagged price, PPI_{t-1}, will have impact on most of the endogenous variables. A one dollar increase in PPI_{t-1} will raise the potato production (OPI_t) by .347 million cwts., and the total exports ($EXPT_t$) by .047 million cwts; it will, however, reduce PPI_t by 23 cents per cwt. Lagged total exports also affect several endogenous variables: An increase of one million cwts. in $EXPT_{t-1}$ will raise OPI_t by .427 million cwts., and $EXPT_t$ by .058 million cwts.; but will reduce PPI_t by 29 cents. An increase of one million dollars in CRP_{t-1} will raise the agricultural investment in the form of implements and machinery by $81 thousand. But its effect on agricultural output will be very small. A one percent increase in CRN_{t-1}, on the other hand, will raise the change in agricultural output by 1.1 percent.

A one percent increase in real farm wages will reduce the change in agricultural output by .25 per cent.

An increase of one million tons in the U.S. potato production ($OPUS_t$) will reduce PPI_t by 86 cents, and $EXPT_t$ by .479 million cwts. A one percent increase in Canadian personal disposable income will raise PPI_t by 2 percent, although it will also raise the external exports ($EXPF_t$), but the increase in $EXPF_t$ will be more than offset by significantly larger reductions in both the internal exports ($EXPRC_t$) and the domestic demand (DDI_t). A one percent increase in the price of substitutes (PSC_t) will raise $EXPRC_t$ and DDI_t by .22 and .06 percent, respectively.

The coefficients of matrix $(1-\Pi_1)^{-1}\ \Pi_2$, if $0 < \Pi_1 < 1$, are called long-run multipliers. The long-run multipliers for some key endogenous

variables, reported in Table 3, describe the changes in the endogenous variables between two stationary states, the changes being generated by a unit change in the level of one exogenous variable.

Growth in the U.S. potato production in the long-run affects the P.E.I. potato sector much more severely than suggested by the impact multiplier: An increase of one million tons in OPUS reduces CRP by 5.96 million in the long-run, compared to a negative effect of 2.25 million in the short-run. On the other hand, the (positive) long-term effect of an increase in Canadian personal disposable income on CRP is about three times larger than that captured by the impact multiplier. Growth in the Netherlands potato production in the long-run has negative effects on OPI, EXPF and EXPRC. Low value of Canadian dollar has strong, positive long-run effects on the external exports and,

TABLE 3

THE LONG-RUN MULTIPLIERS

ENDO-GENOUS VARIABLES	EXOGENOUS VARIABLES						
	OPUS	t	LPDIC	OPN	R	PSC	RDPII
OPI	-.424	.161	1.334	-.063	3.486	.347	
PPI	-.569	-.108	4.401	.042	-2.302	-.229	
EXPF	-.090	-.003	.572	-.174	9.496	-.005	
EXPRC	-.447	.024	-1.399	-.009	.534	1.005	
DDI	-.092	.021	-.850	-.008	.448	.132	.012
FMV	-6.260	-.716	44.794	.283	-15.494	-1.544	
CRP	-5.960	-.680	42.604	.270	-14.749	-1.469	

thereby, its effect on the potato production is also positive, although relatively small. However, higher potato production levels, in turn, have negative effects on the potato price. A one percent depreciation in the value of the Canadian dollar will raise the external exports by 4.5 percent and the potato production by .36 percent. However, it will reduce the price .9 percent.

6. MODEL SIMULATIONS AND SOME FORECASTS

To test the validity of this mode, an ex post (or historical) simulation of the model has been performed.[4] The simulation results have been reported only for the potato sector equations. The simulation, using the reduced form equations, generates values for the endogenous variables which can be compared with the original data series to see how well the model 'tracks' the historical data. To check the predictive ability of the reduced form equations, the root-mean-square (RMS) errors are calculated for each equation.[5] (The RMS for the potato sector equations are reported along with the reduced form equations.) The RMS errors are quite low for all reduced form equations, suggesting that each of the reduced form equations performs well during the estimation time period. The results of the simulation for two endogenous variables, potato price and production, are also shown graphically in Figs. 1 and 2. Looking at the graphs, it can be seen that the simulated series for both variables reproduced the general behaviour of the actual series reasonably well.

Some further simulations of the model have been performed in order to make ex ante forecasts for three important endogenous variables, potato price, production, and external exports, for the 1984-88 period. These forecasts are conditional as they depend upon particular assumptions about the exogenous variables during the forecast period. For each of the three variables, a set

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4. For a detailed discussion of use of simulation models in economics, see Pindyck and Rubinfeld (1976).

5. The formula for the RMS error is

$$\text{RMS error} = \sqrt{\frac{1}{N}\sum_{t-1}^{N}(Y_t^s - Y_t^a)^2}$$

where Y_t^s = the simulated value of Y_t, Y_t^a = the actual value, and N = the number of periods in the simulation.

of alternative forecasts is generated and reported in Table 4.

Forecasts based on the assumptions that $OPUS_t$ and OPN_t follow the respective growth trends; PSC_t grows at 6 percent per year; Canadian personal

TABLE 4

FORECASTS OF POTATO PRICE, PRODUCTION, AND EXTERNAL EXPORTS

	PRICE $ PER CWT.			PRODUCTION MILLION CWT.			EXTERNAL EXPORTS MILLION CWT.			
YEAR	A	B	C	A	B	C	A	B	C	D
1984	5.92	4.54	6.87	15.07	15.07	15.07	4.99	4.77	5.17	6.71
1985	6.44	6.79	7.31	14.81	14.30	15.17	5.01	5.02	5.23	6.73
1986	6.50	6.40	7.57	15.23	15.36	15.56	5.01	5.01	5.28	6.73
1987	6.67	6.69	7.86	15.47	15.43	15.87	5.03	5.03	5.33	6.75
1988	6.81	6.81	8.15	16.75	15.76	16.20	5.05	5.05	5.39	6.77

disposable income grows at 10 percent per year; and R_t remains stable at 73 U.S. cents per Canadian dollar; are called 'Forecasts A'. Forecasts based on the assumption that $OPUS_t$ in 1984 is 10 percent higher than the growth trend, the other assumptions being the same as in 'A', are called 'Forecasts B'. Forecasts based on the assumption that $OPUS_t$ and OPN_t stabilize at the respective average levels of the latest three years are called 'Forecasts C'. Finally, forecast based on the assumption that R_t is 1.54 (i.e., 65 U.S. cents per Canadian dollar) during the forecast period, the other assumptions being the same as in 'A', is called 'Forecast D'.

A comparison of the forecasts under various sets of assumptions provides an illustration of the model's interaction process as defined by the reduced form equations. An increase of 10 percent in the U.S. potato production in one year causes potato price and external exports to decline substantially the same year, and potato production to decline one year later (compare forecasts 'A' and 'B'). It takes two to three years before these variables

return to the 'normal' levels as defined by 'A'. Potato price, production, and exports all receive big boosts if potato production levels in the U.S. and the Netherlands do not expand (compare forecasts 'A' and 'C'). Finally, as can be seen by comparing forecasts 'A' and 'D' for the external exports, the effect of the depreciation in the value of the Canadian dollar on the external exports is also quite significant.

7. SUMMARY

To accomplish the task of analyzing P.E.I.'s potato sector, an econometric model has been developed. The structural equations of the model were transformed into reduced form to derive impact and long-run multipliers. The estimated model provide a basis for quantitative analysis of the effects of changes in exogenous variables (such as exchange rate, potato production levels in the U.S. and Netherlands, Canadian personal disposable income, interest rate, wage rate, and farm capital stock) on the P.E.I. agricultural sector. The model can also be used for productive purposes.

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FIGURE 1.

Historical Simulation: P.E.I. Potato Prices

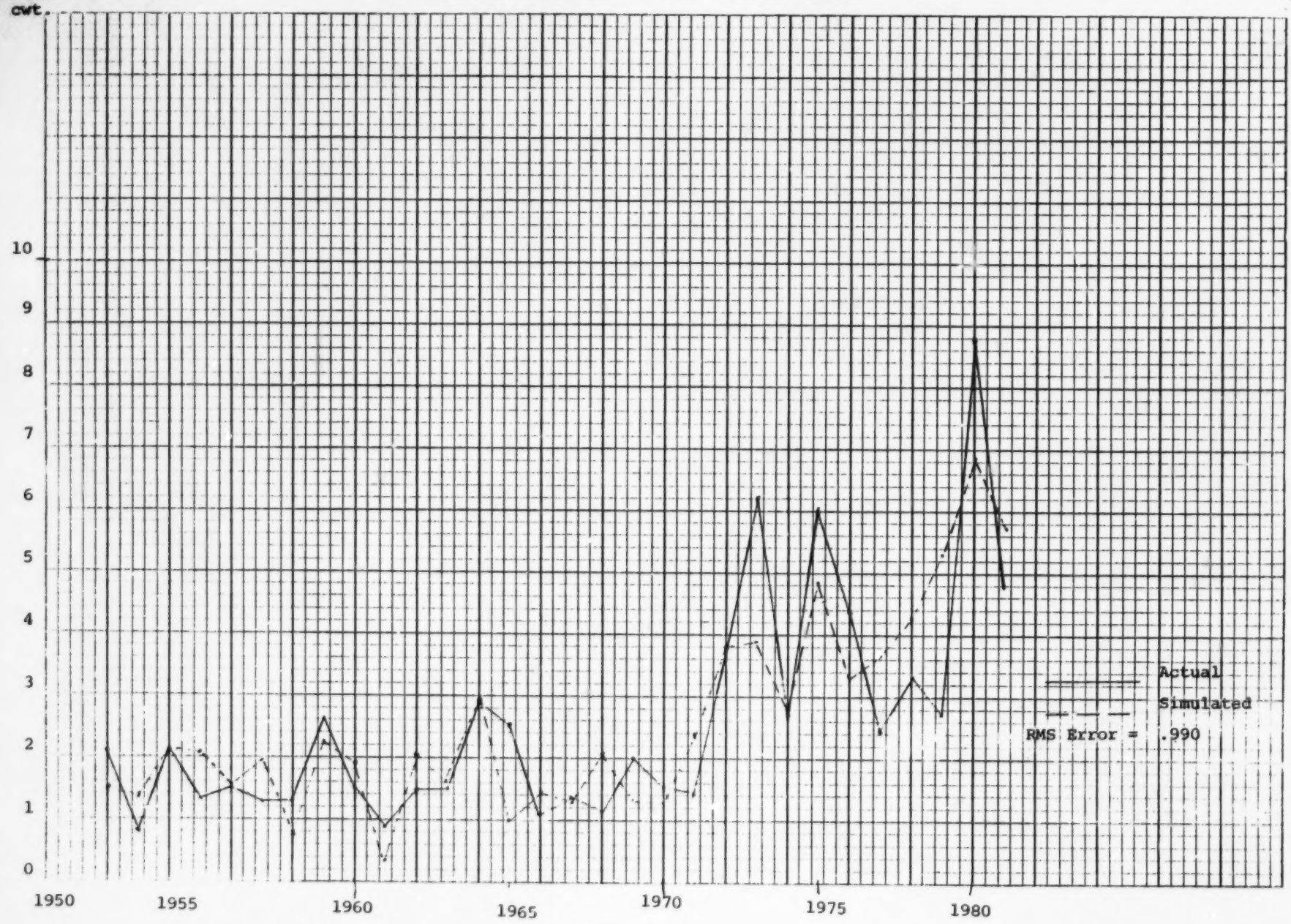
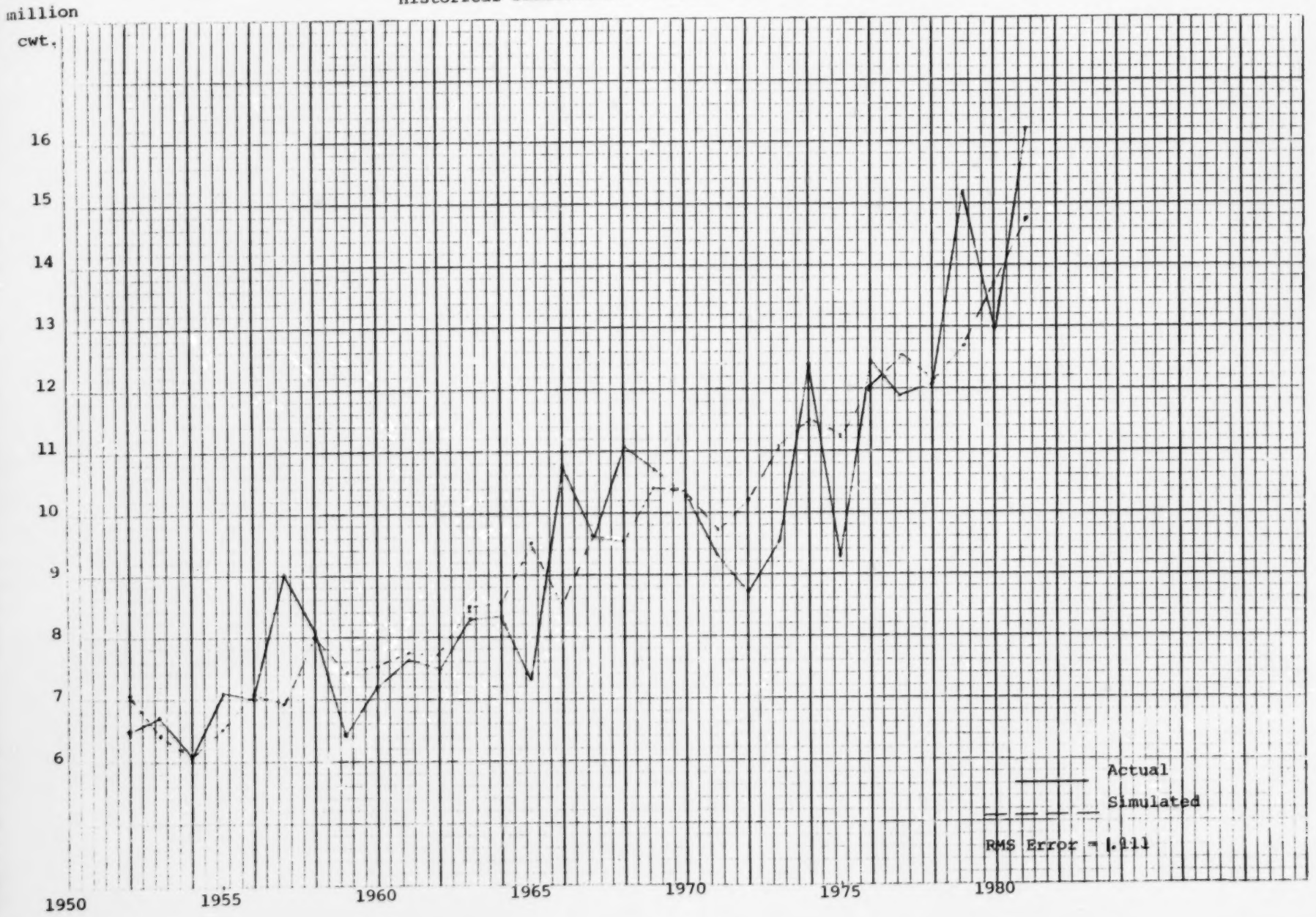


FIGURE 2.

Historical Simulation: P.E.I. Potato Production



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